SUPPLEMENT

TO THE

FIRST EDITION

OF

DR. ARNOTT'S

ELEMENTS OF PHYSICS,

OR

NATURAL PHILOSOPHY;

And in which the few Paragraphs added to the Work since the SECOND EDITION *are distinguished by asterisks* *, *and the page of the second edition to which they belong.*

LONDON:

PRINTED FOR LONGMAN, REES, ORME, BROWN, AND GREEN, PATERNOSTER ROW; AND T. AND G. UNDERWOOD, FLEET STREET.

1828.

N.B. Persons who procure this supplement, are requested at once to make notes of reference to its paragraphs, in the several pages of the volume to which the paragraphs belong. The early edition will then, as to matter of fact or substance, be nearly on a par with the third, although not perhaps as to clearness of style and simplicity of explanation. The first edition issued from the press less complete than might have been, because the author's experience of such business began with it, and because when he had once determined to publish the volume, although his professional duties left him little more than portions of the nights to devote to it, several reasons urged him to do it quickly. He hopes that his second volume, now in progress, will not stand in need of similar apologies.

The first edition is complete for non-professional readers, when the section from page 585 (second edition from page 609) to the end is omitted. The binder will take directions accordingly.

7th June, 1828.

LONDON:
PRINTED BY J. L. COX, GREAT QUEEN STREET.

PREFACE

TO THE SECOND EDITION.

Although paradoxical, it is true, that human knowledge, the more it is accumulated and perfected, is also the more easily acquired and recollected. As an instance we may refer to our present knowledge of the celestial motions. These, to our ancestors, appeared so inexplicable, that to observe and analyze them, some of the most gifted individuals devoted their lives—yet when at last contemplated through the records of many centuries, by the penetrating genius of Newton, they were found all to range themselves under a few simple expressions, easily intelligible and easily remembered by an ordinary mind. Thus, now, not only is the confusion of past times, in regard to astronomy, converted into a scene of beautiful simplicity and harmony, but we are able to predict, with certainty, many of the changes which are to happen in time to come. Facts of this kind make it appear, that the progress which is still to be looked for in the human sciences, instead of threatening men who require a good education with additional labour, promises to convert their necessary labour almost into amusement,—amusement, however, which will lead to the most important results.

The author has thought it necessary to make this observation to meet what has been stated by not a few against his present volume, namely, that it is so simple, or easily

understood, that he must have left untouched many of the important principles of natural philosophy, lest the study of them should prove too difficult for the generality of his readers. Now the fact is, that he has not only included all the general truths belonging to the department of Physics, but has introduced many matters which are not usually found in treatises on the subject:—what he has avoided are matters of inferior, or at least of limited interest. He has, however, availed himself of a circumstance, either not known or not adverted to by former writers, *viz.* that what may be called the *mathematics of common sense or experience*, and which may be expressed in ordinary language—as distinguished from *technical mathematics*, which has its peculiar language, is perfectly sufficient for the explanation of all the great laws of nature. By attending to this truth, and aiming at extreme simplicity of arrangement, he has avoided that abtruse phraseology which is so generally repulsive, and he hopes he has facilitated to many gifted individuals, who would otherwise have been deterred by the idea of difficulty, the study of that one among the four great departments of human science, which, after the department of mind, is the most pleasing in its nature, has attained the highest degree of perfection, is the most fruitful of valuable applications, and when fairly understood in its relation to the others, establishes a lucid order through the whole of the intellectual acquirements.

Astronomy, which is the instance chosen above, is only one of innumerable subjects, which, when imperfectly understood, appear obscure and difficult, but when more fully investigated, become simplicity itself. As an example from the studies of medical men may be mentioned the question of the movement of the blood in the veins, which has lately been discussed in medical societies and reviews with considerable earnestness. In this question, the appeal is necessarily made to the laws of Natural Philosophy, which govern the phenomenon; but because the study of these has been little cultivated by the faculty, more time

has been absorbed in futile disputation and experiment than would have sufficed for acquiring a competent knowledge of the whole body of Physics:—now the single section of Physics, which bears on the point, if understood in a moderate degree, would have caused all the difficulties at once to vanish. The circulation of the blood, again, is but one of numerous and scarcely less important subjects in the medical art, to which Natural Philosophy is the easy and only key.

These last reflections are intended as a reply to a second remark which has been made in some quarters with respect to the present volume, *viz.* that its subject is not of primary importance in medical education. Although no one who had advanced beyond the mere threshold of the study could have held this opinion, the author finds it necessary to advert to it. His labour in preparing the present volume will have been vain, if by it he prove not to his readers that the magnificent fabric of human knowledge has Physics or Natural Philosophy for its foundation; Chemistry for the second department, resting on the first; Physiology, or the doctrine of organic Life, for the third, resting on the other two, and fully intelligible only to the mind familiar with the others; while the science of Mind crowns the whole.

The Author had hoped to be able to publish in the course of this autumn the remaining portion of his Elements of Physics, but the early call for this second edition has prevented him. As the part in question, however, has long been written, there is nothing required in regard to it but what he thinks his leisure will permit him soon to accomplish.

The Author might be accounted insensible to the approbation of his own profession and of society in general, if he allowed the present occasion to pass without alluding to the reception which his book has met. Gratifying indeed has it been to him, and encouraging to the completion of his task. With the desire of making the present volume as worthy as he could make it, of the

approval of those into whose hands it may fall, he has carefully revised it: but as he had previously well considered the subjects, he has found nothing beyond verbal inaccuracies to correct. He has however been able to simplify some of his illustrations, and has here and there added new matter. Whatever of this is of a nature to appear complete in a detached form, will be printed separately for the accommodation of those who have so recently procured the first edition.

It has been mentioned as a fault in the former edition, that no separate enumeration any where appeared of what might be considered novelties in the work. Now many of these are rather in method, condensation, illustration, &c., than in particular subjects. The following, however, may be examined as insulated specimens of new disquisition or suggestion:

30*th Nov.* 1827.

At page xviii, *after "revelation," line 5th from bottom.*

And all his arts are founded on this knowledge—some of them on the single part of Physics, as that of the machinist, architect, mariner, carpenter, &c.; some on Chemistry, which includes Physics, as that of the miner, glass-maker, dyer, brewer, &c.; and some on Physiology, which includes all the rest, as that of the scientific gardener or botanist, agriculturist, zoologist, &c. The business of teachers of all kinds, and of governors, advocates, linguists, &c. &c., respects chiefly the science of mind.

At page xx, *after line 4th from bottom.*

The most complete education as regards mind, can only consist in an acquaintance with *Natural History* and *Science*, and with the signs of ideas, *viz. language*, in one or more of its idioms, and the *visible signs* of letters, cyphers, &c. for representing words. As regards the body, it consists in the formation of various habits of muscular action, as in gymnastic exercises, dancing, riding, in performance on musical instruments, games of address, drawing and painting, use of fire-arms, and other exercises of utility or amusement. By reviewing a table of such matters, each man may see at once what he can know, and what it may suit his particular condition to study.

At page xxii, *after "mind," line* 21*st from top.*

The reason for bestowing much attention on the Greek and Roman languages was good some centuries ago, because then no book of value existed which was not written in one of these languages; but now the case is completely reversed, for he who learns almost any matter of science from old books is learning error, or at the least, knowledge far short of modern erudition. As to the higher mathematics, again, while they merit great honour, as being the instrument by which many useful discoveries have been made, and the conjectures of powerful minds have been confirmed, still a very deep investigation of them is neither possible to the generality of men, nor if it were so, would it be of any utility.

At page xxiii, *after "men," line* 15*th from bottom.*

And even then, the book of nature cannot be compiled, as many encyclopedias have been, by each individual writer taking a distinct part or parts; but by the parts being undertaken conjointly by several, so that he who conceives most happily for students may sketch, he who is learned may amplify and complete, he who is correct may purge, he who is tasteful may beautify, &c. After such a book existed, it would not become the object of talented individuals to write a *new book*—which again would necessarily have the imperfections of an individual attempt—but to assist, under the direction of a superintending council, in perfecting the existing work. The composition of the *Book of Nature* might be a worthy object of rivalry even between nations.

At page 52, *after line* 10*th from bottom.*

The actions of beating a coat or carpet with a cane, to expel the dust; of shaking the snow from one's shoes, by kicking against the door-post; of knocking a dusty book against a table, or shutting it violently—all illustrate the same principle.

At page 66, *after line* 4*th* (* *p.* 63).

It thus appears that the very fact of a spinning-top inclining, causes the point to shift its place, and so that it cannot rest until it come again directly under the centre of the top. It is remarkable that even in philosophical treatises of authority the standing of a top is still vaguely attributed to *centrifugal force.* Hence some persons believe, that a top spinning in a weighing scale, would be found lighter than when at rest ; and many most erroneously hold that the centrifugal force of the whirling, which of course acts directly away from the axis, and quite equally in all directions, when the top inclines, becomes greater upwards than downwards, so as to counteract the gravity of the top. The way in which centrifugal force really helps to maintain the spinning of a top is, that when the body inclines or begins to fall in one direction, the motion in that direction continues until the point in describing its curve has forced itself under the body again.

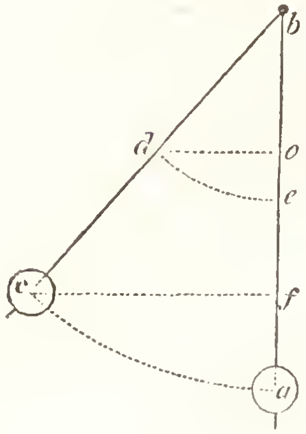
At page 79, *after "increases," line* 21*st.*

This truth is well exemplified by the pouring out of molasses or thick syrup : if the height of the fall be considerable, the bulky mass, which first escapes, is reduced, before it reaches the bottom, to a small thread ; but the thread is moving with proportionate speed, for it fills the receiving vessel with singular rapidity.

At page 82, *after line* 6*th.*

It is shewn in a preceding paragraph, that a body falls four times as far in two seconds as in one, although the velocity at the end of two seconds is only doubled. For the same reason, a body shot upwards with double velocity, rises four times as far as if shot with a single velocity; if with triple velocity, it rises nine times as far, and so forth.

At page 84, *after* " *If,*" *line* 4*th from bottom.*



If a pendulum $b\ a$ be twice as long as another $b\ e$, it has twice as much to fall in its descending arc $c\ a$, as the other in its arc $d\ e$, while in corresponding parts of the two paths, the slope or inclination is always equal.

At page 85, *after line* 14*th.*

To counteract the dilatation or contraction of pendulums from the changing heat of the seasons, various ingenious contrivances have arisen. One of the best of these is the *gridiron pendulum*, as it is called, from consisting of various rods of metal. It renders the different dilatability

by heat of two metals composing it, the cause of unchanged length in the whole. The adjoining sketch may shew that if the central rod of brass (here represented by a *strong* line from *b* to *c*) dilate just as much as the two rods of steel on either side of it do together (the expansion of brass by heat being about double that of steel), it will exactly counteract the lengthening of these, and will keep the ball *d* always at the same distance from the point of suspension *a*.

At page 87, *after line* 12*th.*

As the rate of a clock is influenced by the length of its pendulum, so is the rate of a watch by the size or diameter of its balance-wheel; and heat which retards the motion of a common clock, by lengthening the pendulum, retards the motion of a common watch by dilating the balance-wheel. Man's ingenuity however has found a remedy for the latter case as for the former, *viz.* the contrivance called the *expansion balance-wheel.* Of this the circumference, instead of being a continuous ring, is made

up of two half-rings, each attached by one end only, to a cross bar, and which half-rings being of brass on the outside and of steel within, bend or curl inwards by heat—as a sheet of damp paper bends when held to the fire—and thus diminish the size of the wheel at their loose extremities, so as just to counterbalance its increase by the expansion of the cross bar.

As the motion of a pendulum has relation to the *force of gravity*, so has the motion of the balance-wheel to the *stiffness of the balance-spring;* and the regulator of a watch is merely a pin which bears against the balance-spring, and which, by sliding backwards or forwards, so as to shorten or lengthen the part of the spring left free to bend, changes the degree of its stiffness.

At page 104, *after* " *it,*" *line* 16*th.*

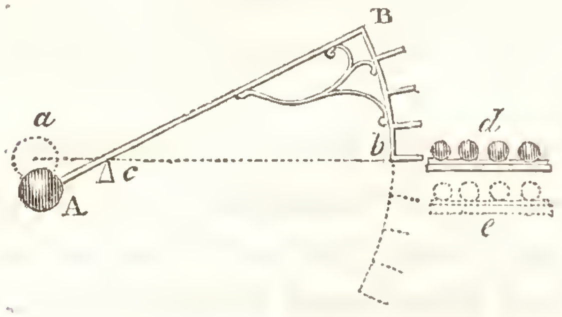
The ascent of a sky-rocket is aided also by the recoil of the rocket from the part of its substance, which is constantly being shot downwards.

At page 105, *line* 6*th from bottom.*

When a billiard-ball strikes directly another ball of equal size, it stops, and the second ball proceeds with the whole velocity which the first had :—the action which imparts the new motion here being equal to the re-action which destroys the old. Although the transference of motion, in such a case, seems to be instantaneous, the change is really progressive, and is as follows. The approaching ball, at a certain point of time, has just given half of its motion to the other equal ball, and if both were of soft clay, they would then proceed together with half the original velocity; but, as they are elastic, the touching parts at the moment supposed, are compressed like a spring between the balls, and by then expanding, and exerting force equally both ways, they double the velocity of the foremost ball, and destroy altogether the motion in the other.

At page 133, *before last line* (* *p.* 136).

Another case of the lever, exhibited in the adjoining diagram, serves well to explain the nature of *mechanical powers* in general. Suppose A to be a weight of four pounds at the end of the rod or lever A B, turning on C as its axis, or fulcrum, and having the arm C B four times as long as the arm CA.: one pound at the end B, would balance the four pounds at the end A (the weight of the lever itself is not regarded here), and with the slightest additional weight would preponderate. Now let us suppose the arc B *b* fixed to the long arm of the lever, and having four projections or shelves from it, on which balls of one pound might rest: if one of the four balls from the plane *d* were to roll upon the first shelf, with one grain more, it would lift A, and would itself descend to plane *e*, one inch below; then a second ball of one pound would occupy the second shelf, and would descend in the same way, and then a third, and then a fourth; and when the whole four had fallen from *d* to *e*, they would just have lifted the four pound weight, at the other end of the lever, one inch. Then, although one pound were seen here lifting four pounds, it would only lift it one-fourth part as far as it fell itself, and the sum of the phenomenon, when ended would be, that four pounds, by falling one inch at the long end of the lever, would have lifted four pounds one inch at the short end. No *mechanical power* or *machine* generates force more than the lever in this case.



At page 134, *after last line* (* *p.* 137).

We must warn the reader, however, that there are many important considerations connected with the practical employment of forces, according to their respective nature, and that of the resistance to be overcome, which

cannot be entered upon in this elementary work. In very many cases there is a great waste or unavoidable loss of force, because the resistance in yielding runs away or escapes from the force, as when a ship runs away from the wind which is driving her, or the floats of a quick moving water-wheel from the stream which turns it. Horses drawing boats or carriages at the rate of five miles an hour, may exert great force; but with a speed beyond twelve miles, nearly their whole effort is required to move their own bodies. As a general rule, although *equal quantities* of force balance each other when applied to parts of a lever or wheel altogether or nearly at rest, still when force is made to act near an axis or fulcrum, to produce considerable velocity in a more distant part, much of it is wasted in pressure against the fixed fulcrum.

At page 143, *after line* 20*th.*

A projecting rod or plank or branch of a tree, with a scale attached to it, might thus be made to answer the purpose of a weighing-beam, by observing minutely how far a certain substance, attached to it, bent it, and then trying what weights would bend it as much.

At page 175, *after line* 4*th.*

It is true also, that a small wheel will sink to the bottom of a hole, where a larger one would rest on the edges as a bridge. It is not true, however, according to the popular prejudice, that the large hind-wheels of coaches and waggons help to push on the little wheels before them: fore-wheels are made smaller, merely to facilitate the turning of the carriage.

At page 176, *line* 10*th from bottom*(* *p.* 178).

When wheels, instead of standing upright, like *a* and *c* shewn here, are made to incline outwards, as is common, owing to the ends of the axle-tree being bent down a little, to give a security against the accident of the wheels falling off, the pull to the horses in deep or sandy roads is much

increased; for an inclining wheel naturally describes a curved path, as is seen when a hoop or wheel-barrow inclines; and the horses, in drawing straight forward, therefore, have to overcome this deviating tendency in all the wheels. This source of resistance is still more remarkable when the inclined wheels have broad rims. Such wheels must be of smaller diameter at the outer than at the inner edge, as the end of a cask is smaller than its middle; then, as the iron hoops or tires which cover the different parts cannot all truly measure the same length of road by an equal number of turns, there will be a constant rubbing or grinding forward of the lesser rings, and a grinding backward of the larger, which must injure the road, rapidly wear the iron, and exhaust the strength of the pulling animals. Such wheels rolling free would describe a circle, as is seen when a thimble or drinking glass or sugar-loaf is pushed forward on any plane surface.

At page 177, *after "rail-road," line* 16*th.*

and the conclusion follows, that although the original expense of forming the level line might considerably exceed that of making an ordinary road, still in situations of great traffic the difference would soon be paid for by the savings, and when once paid, the savings would be as profit ever after.

At page 183, *after line* 8*th.*

In the moon, where the weight or gravity of bodies is less than on earth, on account of her smaller size, mountains might be many times higher than on earth—and observation proves that the lunar mountains are in fact much the highest.

At page 217, *after line* 7*th from bottom.*

Note to the Second Edition.

A distinguished member of our profession, who seems often to have contemplated the human frame under the aspect which elevates the thoughts towards the Creator, has lately published, with the title of *Animal Mechanics*, and as a part of the *Library of Useful Knowledge*, an essay on the perfection of design

manifested in the animal structure. It has been eulogized in many of the public prints, by friends of the diffusion of knowledge, as one of the most admirable productions of modern times; and in consequence has already been demanded by the public to the extraordinary extent of about thirty thousand copies. On comparing this new essay with the present section of the Elements of Physics, to which it has close relation in title, matter, and arrangement, it will be found to have substituted for the detail of certain of the facts adduced here as striking evidences of creative contrivance, an elaborate exposition, constituting nearly half its substance, of what its author has deemed instances of still more profound design than had hitherto been noticed, and still more striking examples, therefore, of God's wisdom and power. Had these instances appeared to me in the same light, it would have been my agreeable task to have incorporated them with the matter of this second edition: but they do not; yet the wide diffusion of the essay, and the authority with which it has come before the public, make it imperative on me, as a faithful teacher, to notice them here, and to state my opinion, that with respect to every one of them the author has fallen into an extraordinary misapprehension of the true nature of his subject, and has attributed to the Creator contrivance or design which is far from being divine. I publish my remarks without hesitation, as regards either the author, or the public-spirited society of which he is a member, assured of their approval, if the remarks are well-founded; but I feel that I shall be doing a kind of sacrilegious violence to many amiable minds, by undeceiving them as to what they have deemed so excellent. The feeling with which the essay is written so naturally interests good men, and the whole is rendered so plausible by the appearance which runs through it of ultra-minute acquaintance with the subject, that thousands of intelligent persons must have yielded up their judgment to the persuasive writer, and must have studied the work with unmixed delight. These are not reasons, however, for concealing the truth, and certainly there is no need to twist or exaggerate truth, for the purpose of proving from the structure of the human body, the wisdom and benevolence which presided at the creation.

The following are part of the errors alluded to. One at least vitiates each chapter.

Chap. I.—*On the Head.*

The author, after stating as usual that the skull has the strength and advantages of the arched form, but not aware apparently that there are kinds of arches so distinct from each other, as to have even direct opposition in certain respects of proportion, &c., hopes to prove the singular perfection of design in the skull, by shewing that it has the peculiarities of the architectural arch, or that of bridges, domes, &c.; and he expresses wonder that men should have been so long in learning to build domes, when every individual carried in his head a model planned by the unerring Architect! Now the architectural arch has material, form, proportions, &c. calculated to resist the force of gravity only, which is unceasing, and acting only in one direction, and which moreover is essential to the stability of the arch, for if this come to incline a little from its natural position, or be shaken by an earthquake, it is instantly demolished. On the other hand, there is the arch of a cask, or barrel, egg-shell, or cocoa-nut, &c., in which the tenacity of the material is many times greater than necessary to resist the influence of gravity, and comes in aid therefore of the curve, to resist forces of other kinds, approaching in all directions, as in falls, blows, unequal pressure, &c. Now the skull, which may be called the oviform shell of the brain, with the face and mouth attached to its under side, is truly an arch of the latter kind, and having very much oftener to bear pressure and blows coming upon it laterally, than from above. A thimble, bee-hive, limpet-shell, &c. are much nearer approximations to the dome than the skull is, because, like the dome, they are open in one direction, yet by reason of their smaller size and the tenacity of their material, they are perfect, without the peculiar securities of the dome. What a mistake then was it for our author to suppose himself proving the perfection of the skull, by trying to exhibit in it peculiarities which, had they really existed, would have been just so many faults!

Chap. II.—*On the Spine.*

Our author holds, that an important analogy exists between the spine and the mast of a ship. Now supposing that there had been some useful lesson obtainable by comparing the crooked, pliant, every where moveable spine, with the straight,

rigid, singularly steadied mast, it will perhaps appear that he was not likely to draw it forth, owing to his imperfect acquaintance with naval matters, as proved by the following assumptions, all of which are errors, and yet all are points or parts of his argument:—that the foremast of a ship being very upright, and far forward, causes the vessel to *tack* or *stay* the better—that the main and mizen-masts are made to *rake* or incline backwards, to diminish the danger to them from the forward pitching of the ship—that masts are *sprung* or broken chiefly by coming into contact with the deck when the rigging is too slack:—that certain boats are the fittest of all to withstand storms, because they are without decks, and therefore cannot injure their masts in the way above alluded to. Our author must have been singularly deceived in some way with respect to these matters, as he may learn by applying to any intelligent seafaring man.

Chap. III.—*On the Chest.*

To prove a hitherto concealed perfection here, he asserts that the elasticity bestowed on the cartilages of the ribs is capable of maintaining respiration, and thereby life, in cases where the respiratory muscles have become too weak to perform their office aright—just as if he were to say, that a spring applied to a pump-handle would continue to lift water, or at least would help, after the worker's arms were tired.

Chap. IV.—*On the Limbs.*

Having mentioned the admirable fact, first pointed out by Borelli, that when a bird sinks down into the sleeping attitude on the branch of a tree, the bending of the limbs so tightens the sinews of the talons, that the foot grasps the branch firmly without the attention or muscular exertion of the animal; he wonders that a similar fact in the human body should have been so long overlooked, *viz.* that when a standing person changes from the soldier's attitude of *attention* to that of *stand at ease*, the bending of the knee and sinking of the pelvis on one side, lifts the other side of the pelvis so as to tighten a ligament or fascia which passes from it to the knee-pan below, and so keeps the leg straight without the fatigue of muscular exertion. Now this is altogether an error. The true reason why the straightened leg requires no muscular support is, that the knee falls a

little behind the general line of the leg, and causes the strain to come upon the posterior ligaments of the joint. And proving that there is no tightened fascia, as assumed, between the pelvis and knee-pan, the latter remains quite loose and moveable—yea, even if the distance between the pelvis and knee-pan be still further increased by bending the knee while standing on the other other leg.

CHAP. V.—*On the Cordage or Tendons.*

In the attempt to prove the tendons to be constructed with consummate skill, he has accumulated many errors. Setting out from the known fact that when a broken rope is spliced, that is to say, has its ends again united by being interwoven with each other, it rarely breaks a second time at the junction; but, not adverting apparently to the circumstance of the rope at that part being double, 1st, he assumes, as a general truth, that plaited ropes are stronger than twisted ropes—contrary to the fact, as is known to every rope-maker; for, what then prevents their plaiting all their ropes instead of twisting them? 2d, He next assumes that the fibres of the tendons are interwoven or plaited, because thereby stronger:—the fact being, however, that they are parallel, although, when torn asunder laterally, a remaining adhesion at a few points may give the appearance of crossing fibres. 3d, He seems not to have been aware that a rope, whether plaited or spliced, will bear much less weight than its constituent fibres loaded singly—the reason being, that in no rope can the tension of the fibres be made so equal that each shall bear its exact share of the load. Plaiting and twisting therefore are defects, and are forced upon men only because the fibres of which ropes are composed are shorter than the ropes, and must be made to cohere, either by being knotted together or by the lateral friction of plaiting or twisting. The chains or wires of a suspension-bridge, which reach from end to end, are neither plaited nor twisted together, which would much weaken them, but are merely secured in parallel contact, as the fibres of long animal tendons also truly are.

The treatise, which we have been obliged thus to criticise, we believe was hastily written, and that the plan was changed more than once in its progress. This will account for its being so little like the valuable other works from the same source.

Note to the Third Edition (* *p.* 223).

I introduced the foregoing note reluctantly, for I knew the treatise examined to be from the pen of Mr. Charles Bell. It would have given me much pleasure to have had rather to speak of his high professional merits, or of some acts of professional charity which at my request he had performed, not less honourably to his generosity than to his skill. I had tried to avoid the necessity, first, by telling him of the errors, with a view to correction in subsequent editions of his work; and afterwards, when during his absence from town it was published without alteration, by representing the matter to a leading member of the *Society for the Diffusion of Useful Knowledge.* This gentleman deemed it necessary for me to publish my note. From the resemblance of the treatise to parts of my work, many persons believed it to be mine, and it was bound up with my volume. I was accordingly blamed for the errors by those who discovered them; or believed to sanction the opinions by those who did not; and by some who knew it to be Mr. Bell's, and believed it faultless, the differences between it and mine were thought defects in mine. By allowing it then to remain uncorrected and unnoticed, I should have allowed error extensively to prevail on subjects which I professed to explain, and I should probably have narrowed the circulation and utility of my own work. The errors would have been grave, coming from a professed writer on physics, while they were comparatively venial, appearing as they did; for the attentive study of physics had not yet been insisted upon in our systems of professional education. Had Mr. Bell spoken to me on the subject while writing his essay, my future notice of it would probably have been unnecessary; and the opportunity for so speaking was given, as a copy of my work, which he had done me the honour to accept, lay upon his table, and at some of my visits, had been the subject of conversation to us.

Mr. Bell could not desire to mislead the public, and therefore could not regret that any published error of his should be corrected. Some friend of his, however, has taken offence at the above criticism, as appears by the eighth number of the "*Medical Gazette;*" and has hoped to serve Mr. Bell, not by disproving the alleged errors, for he does not even touch upon them, but by charging the author of the "Elements of Phy-

sics," with "ignorance,"—"utter incapacity,"—"being a dangerous guide," &c. on the strength of what he supposes three faults, discovered by him in other parts of that work. As his skill in physics, however, seems not to have enabled him to perceive error where it was, the fact of his supposing error where it was not, need not surprise. Accordingly the three portions of the work deemed erroneous by him, *viz.* the illustration of the strength of the scapula, at p. 205, and the proposals of the *Dilator* and *Pneumatic Tractor*, in the last section, are such as I should be pleased to have accounted even favourable samples, and tests of my fitness for the undertaking. I am happy to have to state, that the suspicion that Mr. Bell himself was the author of the attack, is quite unfounded; for he wrote to me on the subject, saying, "the only thing I am anxious about is that you should not suppose I have authorized the counter-statements."

The same defender of Mr. Bell explains the strong resemblance between Mr. B.'s work and mine (which led to the charge of plagiarism in the *Lancet*), by saying that I had taken the whole from previous works of Mr. B. This is nearly as if a friend of any English lexicographer should charge all who write English with copying from his friend's Dictionary; and even if they had used some other. It was not from Mr. Bell's book of Anatomy that I had studied the structure of the human body; and in the present instance I read from the skeleton alone. There is no remark in the few pages of my work which have so unexpectedly to me become thus matter of discussion, which should not occur to almost any person versed in physics, while contemplating the human skeleton. The originality of my essay was in the selection, condensation, and arrangement, under the title (which I believe was new) of *Animal Mechanics*, of some of the most obvious anatomical facts, and in referring these to the physical laws which it was the object of my volume to unfold. That Mr. Bell soon after should have come so near me in these respects, I consider a commendation of my work, and his claiming originality for his own, and not mentioning in his list of previous writings on the subject, mine, which contained the substance of his, except the errors, may have been owing to the hurry with which his was printed, or to his thinking the matter, as in truth it is, of trifling importance.

The same writer further charges it against me, that my reflections on the spine and its diseases, which have been copied from my work into many of the periodicals, are an abstract, unacknowledged, of the late Mr. John Shaw's work on the subject. I should be pleased to think that in my four paragraphs on spinal diseases, I had so happily accomplished, as this censure would imply, the object aimed at throughout my volume, of condensing useful matter; but the fact is, that the paragraphs in question are very nearly the substance of my remarks habitually given to patients under spine disease, before Mr. Shaw's work appeared. My respect for Mr. Bell had led me, from hearing it reported by others, that he descanted ingeniously on the anatomy of the skull, to find room, where few names appeared, for a special commendation of his labours; and had I felt myself called upon, I should not have been behind in regard to Mr. Shaw, for whom, in common with all who knew him, I felt much regard. Mr. Shaw had lent me the skeleton from which in the course of Lectures, of which the present volume records a part, I gave my demonstrations; and which lectures he, with some of Mr. Bell's and his pupils, did me the honour to attend.

At page 237, *after* "*on*," *line* 2*d*.

on the same extent of

At page 249, *line* 6*th from bottom*.

There are some lakes on the face of the earth which have no outlet towards the sea,—all the water which falls into them, being again carried off by evaporation alone—and such lakes are never of fresh water, because every substance, which, from the beginning of time, rain could dissolve in the regions around them, has necessarily been carried towards them by their feeding streams, and there has remained. The great majority of lakes, however, being basins constantly running over at one part towards the sea, although all originally salt, have in the course of time become fresh, because their only supply, being directly from the clouds, or from rivers and springs fed by the clouds, is fresh, while what runs away from them must always be carrying with it a proportion of any substance that remains dissolved in them. We thus see how

the face of the earth has been gradually washed to a state of purity and freshness fitting it for the uses of man, and why the great ocean necessarily contains in solution all the substances that originally existed near the surface of the earth, which water could dissolve:—*viz.* all the saline substances. The city of Mexico stands in the centre of one of the most magnificent plains on the face of the earth, 7,000 feet above the level of the sea, and surrounded by sublime ridges of mountains, many of them snow-capped. One side of the plain is a little lower than the other, and forms the bed of a lake, which is salt for the reasons stated above;—but the lake will not long be salt, for it now has an outlet. About 150 years ago an extraordinary increase of the lake took place, and covered the pavements of the city; an artificial drain was then cut from the plain of Mexico, about sixty miles from the city, to the lower country external to the plain. This soon freed the city from the water; but becoming every year deeper by the wearing effects of the since uninterrupted stream, it is still lowering the surface of the lake, is daily rendering the water less salt, and is converting the vast salt marshes which formerly surrounded the city, into fresh and fertile fields.

At page 258, *after* " *spring,*" *line* 9*th.*

If a spring be as low as the bottom of the porous earth from which it issues, that is to say, as low as the surface of the impermeable clay or rock on which the earth rests, it may drain the whole; but if not, the water will stand at a certain level among the earth as it would among bullets in a pit.

At page 277, *after line* 7*th from bottom.*

There is a mode of catching wild ducks, practised in China, which requires that the catcher be well loaded or ballasted. Light grain being first strewed upon the surface of the water to tempt them, a man hides himself in the midst of it, under what appears a gourd or basket

drifting with the stream, and when the flock approaches and surrounds him, he quickly obtains a rich booty by snatching the creatures down one by one—making them appear as if they were diving, and then securing them below. Each bird becomes as a piece of cork attached to his body.

At page 278, *for last* 5 *lines substitute.*

A floating body, to be stable in its position, must either have its centre of gravity below the centre of gravity of the fluid which it displaces—called the *centre of buoyancy*, or it must have a broad bearing on the water, so that any inclination may cause its centre of gravity to ascend.

At page 284, *after "season," line* 19*th.*

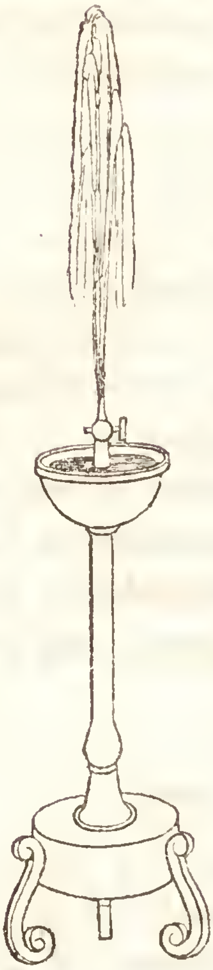
Not only is the extreme of cold below thus prevented, but because water becomes more bulky in proportion as its temperature falls under forty degrees, very cold water remains floating on the surface of a wintry lake, as cream floats on milk, and preserves underneath that warmth which is agreeable to the fishes, just as very hot water in summer remains uppermost, preserving underneath an agreeable coolness.

At page 286, *after "nature," line* 2*d from bottom.*

The atmosphere is about fifty miles high or deep, and therefore, in relation to the bulk of the earth, is as a covering of one-tenth of an inch in thickness to a common library globe of a foot in diameter.

At page 296, *after line* 2*d.*

A table-lamp thus, by the pressure of condensed air, may be supplied with oil from a reservoir far below the wick: and lately an enema-syringe, and a shower-bath have been constructed on the same principle.



At page 303, *after line* 5*th.*

This fountain may have its parts concealed under a variety of graceful forms, as that here represented; and then it becomes a beautiful ornament among flowers in a summer drawing-room.

It may be made to play for an hour or more, and will always recommence on the water being shifted from the low to the high reservoir.

At page 320, *after "relation," line* 15*th* (* *p.* 331).

This truth is well exemplified in what may be called the *syphon-paradox*, an exact counterpart of the paradox of the "Hydrostatic Bellows," already explained. The syphon-paradox may be exhibited by reversing the apparatus of the bellows. If this apparatus be filled with water in the ordinary way (see page 232), and be then turned so that the tube becomes like the long leg of a syphon, the little stream of water issuing from it at *a* will lift as great a weight suspended *from* the board *d*, as the same slender column in the standing position can lift *upon* the board. Farther illustrative of the atmospherical pressure exerted in producing this effect and in rendering a syphon active, we may advert to the striking fact, that a long small tube of water screwed into the side or bottom of a close cask of water so as to communicate with it, and then allowed to discharge like the long leg of a syphon,

will cause the cask to be burst inwards, just as the same tube screwed into the top of the cask, as represented at page 231, would cause the cask to be burst outwards.

At page 332, *after line* 18*th* (* *p.* 343).

A barometer is of great use to persons employed about those mines in which *hydrogen gas*, or *fire-damp*, is generated and exists in the crevices. When the atmosphere becomes unusually light, the hydrogen being relieved from a part of the pressure which ordinarily confines it to its holes and lurking-places, expands or issues forth to where it often meets the lamp of the miner, and explodes to his destruction. In heavy states of the atmosphere, on the contrary, it is pressed back to its hiding places, and the miner advances with safety.

At page 336, *after "recover," line* 10*th.*

In the elevated plains of South America, the inhabitants have larger chests than the inhabitants of lower regions—exhibiting another admirable instance of the animal frame adapting itself to the circumstances in which it is placed.

At page 349, *after "that," line* 10*th.*

high-pressure steam is merely *condensed steam*, as *high-pressure air* is *condensed air*, in other words,

At page 357, *after "alone," line* 7*th* (* *p.* 369.)

—the same steam thus doing double work or more. All the advantages of the two cylinders, however, are obtainable from the single cylinder as now used in most of the Cornish mines. Steam of about 40lbs. pressure on the inch is admitted to the cylinder, until the piston is driven one-third of its way, and the valve being then shut, the same steam is left to finish the stroke by its expansion alone. The pressure of the expanding steam gradually diminishes, it is true, in proportion as the volume in-

creases; but in pumping water there is a great saving of time, from having the power more intense at the beginning of the stroke, when the vast mass of water and machinery has first to be put into motion.

At page 372, *after line 5th.*

but Mr. Daniel (see his excellent work, entitled Meteorological Essays) has lately given to the philosophical world a correct and simple instrument for the purpose. It depends on the principle explained above, that whenever a body in the atmosphere has a temperature below that at which the quantity of watery vapour in the air around can be maintained in the aeriform or invisible state, dew forms on the body. By cooling a bulb of glass until moisture begins visibly to settle upon it, and then noting the temperature on an enclosed thermometer, the proportion of water mixed with the air is discovered.

At page 378, *after "abandoned," line 20th.*

A balloon has since been thought of as a means by which travellers might obtain information, while penetrating into unknown countries, like the almost interminable plains of *Australasia.*

At page 382, *after line* 13*th.*

A piece of burning paper thrown upon the top of a half-extinguished fire, often makes it blaze afresh, by causing a more rapid current of air to pass throught it from below.

At page 394, *after line 23d.*

The reason why the trade-winds at their external confines, which are about 30° from the sun's place, appear almost direct *east* and become more nearly *north* and *south* as they approach the central line, is, that at the confine they are like fluid coming from the axis of a turning wheel, which has approached the circumference, but has not yet

acquired the velocity of the circumference; while, nearer the line, they are like the fluid after it has for a considerable time been turning on the circumference, and has acquired its rotary motion, appearing at rest as regards that motion, but still leaving sensible any motion in a cross direction.

While, in the lower regions of the atmosphere, air is constantly flowing towards the equator and forming the steady trade-winds between the tropics, in the upper regions there must of course be a counter-current distributing the heated air again over the globe. Accordingly, since reasoning led men to expect this, many striking proofs have been noted. At the summit of the Peak of Teneriffe, observations now prove that there is always a strong wind blowing in a direction contrary to that of the trade-wind on the face of the ocean below. Again, the trade-winds among the West-India Islands are constant, yet volcanic dust thrown aloft from the Island of St. Vincent, in the year 1812, was found, to the astonishment of the inhabitants of Barbadoes, hovering over them in thick clouds, and falling, after coming more than 100 miles directly against the strong trade-wind, which ships must take a circuitous course to avoid. Persons sailing from the Cape of Good Hope to St. Helena, often find the sun hidden for days together by a stratum of dense clouds passing southward high in the atmosphere; which clouds consist of the moisture raised near the equator with the heated air, and becoming condensed again as it approaches the colder regions of the south.

At page 395, *after "wind," line 7th.*

In many situations beyond the tropics the westerly winds, which are merely the upper equatorial currents of air falling down, are almost as regular as the easterly winds within the tropics, and might also be called trade-winds:—witness the usual shortness of the voyages from New York to Liverpool, and the length of those made in the contrary direction.

At page 403, *after "it," line* 12*th from bottom.*

and when only twice as much water is forced out, there is still four times as much work done, because each particle issues with twice the force or velocity.

At page 406, *after line* 13*th.*

It is said that boats having to reach the shore through a raging surf, have been preserved by the crews first spilling a cask of oil in the offing.

At page 415, *after line* 3*d from bottom* (* *p.* 432).

Thus, even if the resistance at the bow of a vessel were all that had to be considered, the force of one hundred horses would only drag the vessel ten times as fast as the force of one horse. But there is another important element in the calculation, *viz.* the lessening of the usual water-pressure on the stern of the vessel as she moves forward, on account of which, the force required to produce an increased velocity is still considerably greater than as noted in the table.

At page 421, *after line* 8*th from bottom.*

The explanation is, that a flat or plane surface throws the particles of fluid almost directly outwards from its centre to its circumference—the convex or wedge-like surface again, while displacing them just as far, still does it more slowly, and therefore with less expenditure of force, in proportion as its point is in advance of its shoulder or broadest part—and a concave surface must give to some of the particles a forward as well as a lateral motion. The shape of the hinder part of a solid moving through a fluid is of importance for corresponding reasons.

At page 429, *after line* 5*th from bottom.*

The reason why a ship generally sails faster with the wind from one side, than when it is from directly astern, is, that in the former case all the sails are acting, although

individually not to the best advantage, while in the latter, the sails in front are becalmed by those behind them. A ship with a side-wind may move faster than the wind, as is often true of the outer extremities of a windmill's vanes.

At page 435, *after line* 8*th from bottom*..

An exhibition has lately been made (October 1827) of a car drawn along the highways by kites. That they might ascend to a great elevation, where the wind is generally stronger than below, they were attached to each other in a row, so that the second kite mounted as if its cord were held by a hand at the first, the third as if rising from the second, and so forth. The projector of this novelty hoped that he had pointed out a most valuable means of travelling across extensive plains, sandy deserts, tracts of snow, &c., and, in all cases, nearly with the speed of the wind.

At page 468, *after line* 9*th from bottom.*

A superstitious man sleeping in the upper story of a lofty house, had long heard, during the stillness of night, a singular beating noise near the head of his bed. There was nothing going on near him, or indeed in the whole house, to account for it, and he at last deemed it supernatural. Accident, however, discovered that in a cellar at the bottom and outside of the wall against which his bed stood, there was a wooden clock hanging, of which the sound became audible aloft.

At page 477, *after line* 15*th.*

The wide-spread sail of a ship, rendered concave by a gentle breeze, is also a good collector of sound. It happened once on board a ship sailing along the coast of Brazil, 100 miles from land, that the persons walking on deck, when passing a particular spot, always heard very distinctly the sound of bells, varying as in human rejoicings. All on board came to listen, and were convinced,

but the phenomenon was mysterious and inexplicable. Months afterwards it was ascertained, that at the time of observation the bells of the city of St. Salvador, on the Brazilian coast, had been ringing on the occasion of a festival—their sound, therefore, favoured by a gentle wind, had travelled over 100 miles of smooth water, and had been brought to a focus by the sail in the particular situation on the deck where it was listened to.

At page 550, *after* "*required,*" *line* 1*st.*

It is most important to remark here, that if air be injected into the lungs, either in too large quantity or very suddenly, instead of recalling or sustaining life, it is as certain a means of killing as a dagger driven through the heart. This truth has been but lately known, and ignorance of it has probably decided the fate of many persons, treated with a view to recovery after submersion. The operator should reflect that he is dilating the delicate air-cells of the lungs with the force of an hydraulic press; and that if he do so very suddenly, although little, he still may rupture many small blood-vessels, before they can empty themselves so as to yield. In a bellows for the purpose of artificial respiration, there should be the means of checking its opening to suit the capacity of the patient's chest, and there should be a cock in the pipe or nozzle, to regulate the speed of the passing air.

At page 565, *after line* 10*th from bottom* (* *p.* 589).

Should stuttering ever arise from the attempt being made to speak while drawing air into the chest (which I much doubt), it may then be avoided by filling the chest well before beginning to speak.

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